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The turning point of solar photovoltaic industry in China: Will it come?

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ABSTRACT

Influenced by the international environment, price of photovoltaic (PV) products has continued to drop in recent years. The production enthusiasm of manufacturers was affected, and the market was in depression at once. To realize the expansion of domestic market, China has implemented many incentives since early 2009. This paper reviews the present status and development trend of the Chinese PV industry. It focuses on the turning point problem and draws the conclusions: First, there are still some obstacles to overcome, the key ones are the too low PV product price, industry overcapacity, unbalanced industrial demand and supply, cutbacks in foreign PV market and uncompetitive technologies. Second, the turning point of PV industry in China will come in the future if the problems in PV industry can be solved and the large-scale of the industry can be achieved. Third, the Chinese government is gradually clearing up the obstacles of the development of PV industry, and the turning point is on the way, maybe not later than 2020. At the end of the paper, suggestions are offered as references for the government.

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Contents

1. Introduction

1.1. Background

In 2008, the global financial crisis emerged, which resulted in foreign PV market shrinking rapidly. Chinese PV companies faced a

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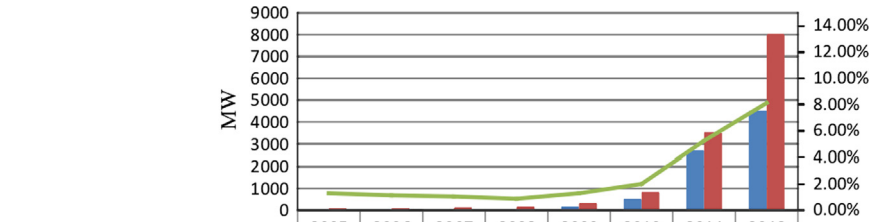


	2005	2006	2007	2008	2009	2010	2011	2012
China's annual installation	8	10	20	40	160	500	2700	4500
China's cumulative installation	70	80	100	140	300	800	3500	8000
Share in the world's installation	1.30%	1.14%	1.05%	0.88%	1.30%	2.00%	5.25%	8.12%

Fig. 1. China's PV capacity and share in world's (2005–2012).

bad time for entirely dependent on foreign orders at that time. A large number of enterprises have ceased production and even closed down. Then in 2009, European debt crisis happened. Demand in the market for PV products continued to be weak. What's the worse, anti-subsidy investigations were conducted by EU and the USA in 2012, as China dumped polysilicon to U.S., Germany and Korea at price below the cost.

Since early 2009 many incentives have been implemented in China, and then the domestic market expanded gradually. China is now the world's PV manufacturing center. In 2012, China's production capacity of polysilicon was 158,000 t, representing 43% of the global total. The PV module capacity was 37 GW, taking a share of 51% in the world. The installation of PV power increased soon these years. The annual installation was 4.5 GW, and the cumulative PV installation reached 8 GW at the end of 2012 which accounted for 8% of the 98.5 GW in the word (Fig. 1).

What's more, many policies have been issued recently. In August, National Development and Reform Commission (NDRC) released two documents. The documents aimed at expanding the domestic PV market and increasing the demand of PV products. They clearly issued three new types ground station price subsidies of $0.1473/kW h,[1] $0.155/kW h and $0.1637/kW h. Subsidy for distributed PV plants is $0.0688/kW h. The additional renewable energy tariff would rise from $0.0013/kW h to $0.0025/kW h. The price subsidy is much higher than previously expected. On July 15, the State Council issued "the Several Recommendations to Promote Healthy Development of Photovoltaic Industry" (short for "Recommendations"). It set the new PV power installation target as 21 GW instead of 10 GW and 15 GW that were issued one year ago from 2013 to 2015, and the total installation was planned as 35 GW by 2015. If the goal could be achieved, China will set off a new round of creating new capacity next few years. Thus, PV industry will get an opportunity to accelerate its own development. It seems that China's PV industry will completely get rid of the bad conditions and the turning point will come. Will it come true?

1.2. Literature review

Many factors influence the development of PV power industry. Sufang et al. [1] believe the price of PV products has been declining steadily along with the increasing output of solar PV industry, though the historically high cost of PV has restricted China's PV market growth. Kaijun et al. [2] indicate the introduction of national policies can promote the PV market installation. But Xiande et al. [3] confirm the cost of PV power generation is still too high to compete with the conventional electricity. Zhen-yu et al. [4] summarize that in China, the main factors that affect the PV power industry are technologies, industry plan, laws, price and incentive policies. Ruirui, Xiaohua and Lei [5–7] think that Financial aid, scientific support, and market demand are very important for the further development of the industry. Lesourd [8] points out only through cutting down the cost can the PV industry get sustainable development. Xindong [9] puts forward that strategic emerging industries are majorly based on the technological breakthroughs and significant development demands.

As to the future of China's PV power industry, most of the scholars believe that it has a bright prospect. Ning [10] thinks further decline will continue in the PV power cost, and PV power is expected to be competitive with conventional power in 2020. Also, the domestic PV market scale will gradually expand. Li [11] predicts that the technology breakthrough of thin film solar cell enables the market share expansion of thin film solar cell and it will also change the industry deployment.

However, some problems exist in China's PV industry. Lei and Chun [12] find the cost of PV power generation in China is still much higher than conventional electricity. Lei and Yan [13] insist that China's PV industry is export-dominated. Junrong [14] thinks that market risk, cost risk and policy risks exist in the PV industry. Yongqiang and Yuzhe [15,16] think China's PV technology lies at a relatively low level and the industry is unbanlanced. Lina [17] analyzes the overcapacity problem in the perspective of corporate behavior and market structure. At last it puts forward to controlling the number of enterprises to enter, promoting technological innovation and optimizing the industrial structure. Li [18] thinks the basic indicator of overcapacity is capacity utilization. Institutional mechanisms and other non-market factors are more prominent on the impact of overcapacity. Pu [19] puts forward that excessive local incentive policies exist in China's solar PV industry and unbalanced industry development also should be taken into consideration.

This paper focuses on the turning point of China's PV industry. It will base on previous studies and add the newest data in 2012 or 2013. The work is organized as follows: Section 2 provides an overview of China's solar PV development. It includes the status of policies, market which includes price, capacity utilization, export of PV products and technologies. Section 3 shows China's development trend and discusses whether the "turning point" will come. The last section answers the question in the title and gives out the suggestions.

2. Status quo

2.1. Policies

Appropriate policies can promote sustained and coordinated development of PV industry. These include the Energy Law (2006) and relevant renewable energy policies (mainly from 2006–2008), the support for research and development (R&D) (2006–2010), the programs subsidy (the Brightness Program (1996), the Township Electrification Program (2002), the Rooftop Subsidy Program (2009), the Golden Sun Demonstration Program (2009), the PV Concession Program (2009)), the most recent policies—the national Feed-in tariff

[1] Exchange rates: $1 = 6.1082 yuan. The further occurrences will be the same.

(FIT) scheme (2011, 2013), the regulation for market access(2013) as well as the tax preferential policy (2013).

2.1.1. The renewable energy law and related policies

In 2005, China promulgated the Renewable Energy Law, which became effective on January 1, 2006 and was amended in 2009. It created for the first time a national framework for the promotion of renewable energy in China. Pursuant to the law, a series of renewable energy policies were issued later. These included the Provisional Administrative Measure on Pricing and Cost Sharing for Renewable Energy Power Generation (2006), the Tentative Management Method for Renewable Energy Development Special Fund (2006), the Medium and Long Term Renewable Energy Development Plan (2007) and the 12th Five-year Plan of Renewable Energy Development (2012) and so on.

The Plans set the national targets for the development of renewable energy. It signified that the government should ensure a certain market scale. The Tentative Management Method provided an on-grid electricity price mechanism for the renewable that was similar to a national feed-in tariff system. The price paid renewable electricity generators a fixed, additional amount for each kilowatt hour of generated electricity. The Provisional Administrative Measure indicated the cost of renewable energy generation and grid connection should be divided among utilities and electricity end users.

2.1.2. The supports for research and development (R&D)

The Ministry of Science and Technology (MOST) supported R&D in universities, research institutions and firms, in order to assist each "Five Year Plan" issued by the central government. It supported R&D in PV sector mostly through the programs as below Table 1. 863 Programs focused on the PV power market application including the on-grid utility-scale PV in desert and thin-film PV, while the Key Technologies of R&D Program concentrated on the upstream such as equipment manufacturing of crystalline silicon PV. On April 26, 2013, a key project of 863 Program got initial results: the laboratory conversion efficiency of crystalline silicon cell was up to 20% or more.

2.1.3. The program subsidies

2.1.3.1. The Brightness and Township Electrification Programs. The Brightness and Township Electrification Programs were the major driving forces for solar PV market expansion in China in the late 1990s and early 2000s. In 1996, China's former State Planning Commission formulated and put forward plans for the Brightness Program, as Table 2 shows. The program aimed to provide this populace with average PV capacity of 100 W per person, which was at that time equivalent to China's average installed capacity per person.

In 2002, the National Development and Reform Commission (NDRC) initiated its Township Electrification Program. Out of the 1065 towns included in the program, 688 were targeted for the PV power stations construction, with a total installed capacity of 20 MW. Since the start of the project, great majority of solar PV stations were constructed then and are generating power now.

2.1.3.2. The Rooftop Subsidy Program and Golden Sun Demonstration Program. China's PV industry is always relying on overseas markets, and thus faced with large trade frictions with the USA and the EU. The Chinese government has rolled out measures to boost its domestic solar market. Two national solar subsidy programs—the Rooftop Subsidy Program and the Golden Sun Demonstration Program have been initiated.

In March 2009, the Ministry of Finance (MOF) and the Ministry of Housing and Urban-Rural Development of China (MOHURD) announced the Solar Roofs Program. The expense was covered by the Renewable Energy Development Special Fund. In July, the MOF, the MOST and the National Energy Administration (NEA) initiated the second national solar subsidy program—the Golden Sun Demonstration Program. It supported more than 500 MW solar PV projects within two to three years. The former emphasized generation efficiency, the latter encouraged on-site consumption of on-grid systems (Table 3).

As of 2012, both programs have gone through four phases. The approved capacity of solar building projects (BIPV and BAPV projects) under the two programs has been 551.2 MW totally. And 455 projects in total have been approved under the Golden Sun Demonstration Program, with a total capacity of 2872 MW

Table 1
Support for R&D.

Year	Program	Assistance object	Subsidy
2006	863 Program	R&D of BIPV, CPV, on-grid utility-scale PV in desert and thin-film PV	$26.1943 Million funding (2006–2010)
2006	973 Program	Basic scientific research for long-term development	About $4.9114 Million funding (2006–2010)
2006	Key Technologies R&D Program	R&D of equipment manufacturing of crystalline silicon PV	$3.2743 Million funding
2009	The Fund for Technology Based Firms	Innovation and investment of small high-tech firms	$3.2743 Million in total: Small start-ups can get $0.0327–$0.0655 million R&D and demonstration projects small firms can receive no more than $0.1637 million Investment projects of small firms in designated industries can receive $0.1637–$20.3274 million

Table 2
Brightness and Township Electrification Programs.

Year	Program	Target	Focus	Investment
1996	Brightness Program	Provide power for daily needs to the population of 23 million in China without access to electricity	Provinces of Western China, Xinjiang, Inner Mongolia, Gansu, Qinghai, and Tibet	About $1.637 billion
2002	Township Electrification Program	Meet the power needs of public utilities and residents of unelectrified townships	Remote, border regions of Western China	$0.7694 Billion ($0.4846 billion is provided by government bonds)

Table 3
Comparison of Rooftop Subsidy Program and Golden Sun Demonstration Program.

Date	Program	Projects	Subsidy
March 2009	Solar Roofs Program	The scale of a solar PV project be no less than 50 kW The generation efficiency of monosilicon PV products, polysillicon PV products and amorphous silicon PV products exceed 16%, 14%, and 6% respectively	$2.4555/W for rooftop systems and $3.274/W for BIPV systems 50% of the bidding price for the supply of critical components
July 2009	Golden Sun Demonstration Program	The system size to be no less than 300 kW	50% of the total cost for on-grid systems and 70% of the total cost for off-grid systems Excess electricity could be sold to the utility at the local tariff of desulfurized coal generation

Table 4
Solar PV building projects and Golden Sun Demonstration Program.

Year	Solar PV building projects in China				Golden Sun Demonstration program			
	Approve projects	Approved capacity (MW)	Subsidy ($/W)		Approved projects	Approved capacity (MW)	Subsidy ($/W)	
			BIPV	BAPV			Building	Off-grid
2009	111	91	20	15	98	201	14.5	20
2010	99	90.2	17	13	50	272	1.8826	16
2011	106	120	12	–	140	690	C-Si: 9.0 a-Si: 8.5	
2012	–	250	9	7.5	167	1709	5.5	> 7.0
Total	–	551.2	–	–	455	2872	–	–

Table 5
Two bidding of Solar PV Concession Program.

Date	Stage	Assistance object	Standard
March 2009	First bidding	10 MW project in Dunhuang city, Gansu Province	On-grid price of $0.1748/kW h
June 2010	Second biding	13 Projects with an aggregate capacity of 280 MW	Successful bidders should complete the construction in 24 months Have exclusive right to operate the plant for 25 years with a on-grid price On-grid price from $0.1193/kW h to $0.1622/kW h

(Table 4). These two subsidy programs clearly demonstrate China's determination to support the adoption of solar PV.

2.1.3.3. The solar PV Concession Program. In order to promote the expansion of the domestic PV market and test the benchmark price of domestic PV power generation, the NEA has sponsored two rounds of public tender for solar power projects in March 2009 and June 2010 (Table 5) since 2009. The first bidding was just for 10 MW projects in Dunhuang city and Gansu Province. However, the second round projects consisted of lager capacity and more places. It included 60 MW in Inner Mongolia, 60 MW in Xinjiang, 60 MW in Gansu, 50 MW in Qinghai, 30 MW in Ningxia and 20 MW in Shanxi, etc. What's more, the On-grid price was going down from $0.1784/kW h in 2009 to $0.1193–$0.1622/kW h in 2010. As a result, China's Solar PV electricity price was significantly reduced from $0.6549/kW h in 2008 to $0.1637/kW h or less in 2010.

2.1.4. The most recent polices

2.1.4.1. The national FIT scheme. In July 2011, the National Development and Reform Commission (NDRC) announced its first nationwide FIT scheme for solar PV development, which was named "Notice on Perfection of Policy Regarding Feed-in Tariff of Power Generated by Solar PV" (Table 6). It was aimed at boosting China's domestic solar industry and increasing the share of solar power in China's energy portfolio. It also announced the benchmark price was $0.1883/kW h.

"The Notice of Playing a Role in the Price Lever to Promote the Healthy Development of the PV Industry" was issued after two years. There were three benchmark prices in different zones according to the regional difference and cost variation (Fig. 2). It also provided subsidies of $0.0688/kW h for distributed PV power, and definite subsidies period of 20 years for both benchmark price and price subsidies. From Table 6 we also can see, the benchmark price was going down from $0.1883/kW h in 2011 to $0.1555–$0.1637/kW h in 2013. Additionally, the PV distributed power price was firstly introduced in the FIT scheme.

2.1.4.2. The regulation for market access. In order to adjust the China's PV industry structure and to encourage management and technologies innovation, the Ministry of Industry and Information Technology led "PV Manufacturing Industry Norms condition" (short for "Condition") on September 17, 2013. "Condition" focused on PV wafers, cells and other manufacturing components and would be officially implemented on October 17. It set requirements on production layout, production scale and technology.

PV manufacturing enterprises should be qualified for the independent R&D institutions of provincial level (or higher level), technology centers or high-tech enterprise. Moreover, the cost for research and process improvement must be not less than 3% of total sales and not less than $1.6371 million every year.

The production conversion efficiency of new and expanded enterprises was clearly defined: the conversion efficiency of polycrystalline

Table 6
Comparison of FIT scheme in 2011 and 2013.

Date	Law and regulation	Price standard	Benchmark price	Time limit
July 2011	Notice on Perfection of Policy Regarding Feed-in Tariff of Power Generated by Solar PV	(1) Projects approved prior to July 1, 2011, which have completed construction and have achieved commercial operation prior to December 31, 2011 (2) Tibet	$0.1883/kW h	No
August 2013	Notice of Playing a Role in the Price Lever to promote the Healthy Development of the PV Industry	(1) Projects approved after September 1, 2013 (2) Projects approved before September 1, 2013 and which have completed construction and have achieved commercial operation after January 1, 2014	Zones I: $0.1473/kW h Zones II: $0.1555/kW h Zones III: $0.1637/kW h	20 Years

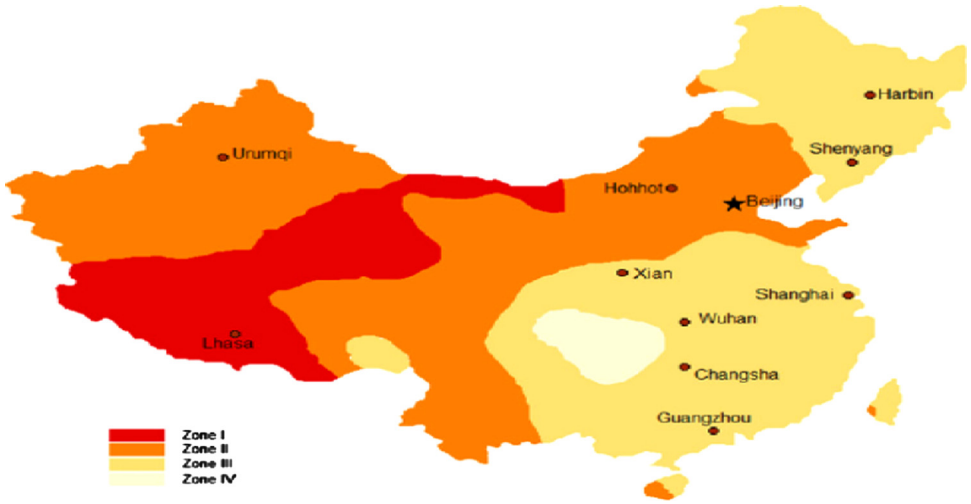


Fig. 2. Solar energy resource distribution in China. .
Source: [20]

Table 7
Tax preferential policy for PV power generation.

Date	Law and regulation	Tax type	PV power generation
January 2008	Implementation Regulations of the PRC Enterprise Income Tax Law	Income tax	The first 3 years for duty free The next 3 years for tax in half
October 2013	Notice on PV power' VAT	VAT	The instant levy and instant Refund 50% 2013.10.1 to 2015.12.31

silicon cells and monocrystalline silicon cells are respectively not less than 18% and 20%, the conversion efficiency of polycrystalline silicon modules and monocrystalline silicon modules are not lower than 16.5% and 17.5% respectively.

The PV manufacturing enterprises and projects that could not meet the requirement of "conditions" would not be supported by export tax rebate or the domestic policy support. In addition, they must achieve the requirements of this specification through mergers and acquisitions or technological innovation according to the national industrial policy guidance.

2.1.4.3. The tax preferential policy. The enterprises of PV power generation enjoy the income tax preferential, which means that the income tax for the qualified enterprises will be exempted from the first year to the third year after they obtain the operating income, and the income tax are only levied by half for the next 3 years (Table 7).

For the value added tax (VAT), the PV power generations enjoy the preferential policy which means the instant levy and the instant refund. Currently, the VAT of China's PV power is 17%, and it will be reduced to 8.5% after the implementation of VAT.

2.2. Market

2.2.1. Price

Price (weighted average price) of crystalline silicon component in domestic market seemed to be close to the bottom after going down quickly since the end of 2008 (Fig. 3). For example, the price at the third quarter of 2008 was $3.85/W and it fell to $1.73/W at the first quarter of 2010 with a decrease of 58%. From the fourth quarter of 2011 to the second quarter of 2013, the price continued to decline from $1/W to $0.62/W with a fall of 38%.

PV module is an important part of solar power system, the price of which declined in the past years (Fig. 4). The price declined sharply in 2008 mainly because of the sudden decrease of global market demand caused by the financial crisis, the market limitation in Spain, and the sharper cut back of the FIT in Germany. Meanwhile, the increasingly sophisticated manufacturing technologies, the advance in production efficiency and management level also decreased the price of PV industry chain gradually in recent years [22]. In 2012, the average price (or the cost) of domestic large-scale ground station system has already been cut as low as $1.5–$1.8/W.

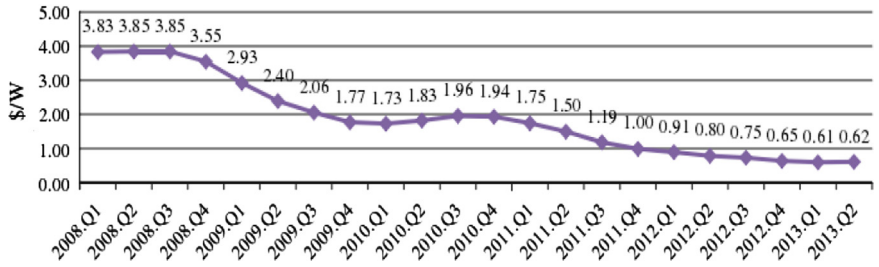


Fig. 3. Price (weighted average) of crystalline silicon component in Chinese market.
Source: [21].

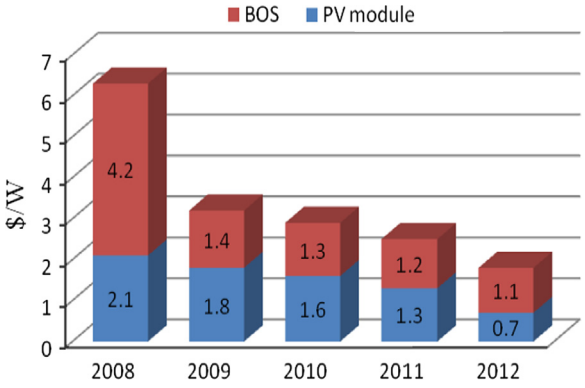


Fig. 4. System price (or cost) of China's massive ground PV power plant.
Source: [22].

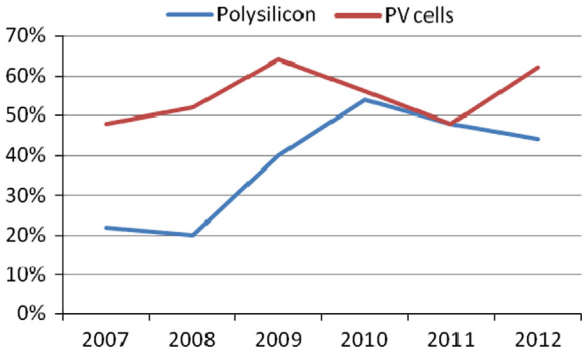


Fig. 5. Production utilization rate of polysilicon and PV cells.
Source: [22].

2.2.2. Capacity utilization and supply-demand gap

The development of China's PV industry started in 1958 and began to enter into application stage in the 1970s. It was not actually industrialized until the middle 1980s when two single crystalline silicon solar cell production lines were introduced and the large-scale utilization period came.

PV manufacturing market seemed to develop too fast in the past years. During the 11th Five Year Plan (11th FYP), the production of solar cell in China had developed at a growth rate of more than 100% and had ranked the first in the world for five consecutive years, and crystalline silicon cells accounted for more than 95% of total solar cell production. Capacity utilization of polysilicon and PV cells from 2007 to 2012 is illustrated in Fig. 5.

Fig. 5 displays that capacity utilization of the PV products was no more than 60%, and capacity utilization of polysilicon was just about 50% in recent years. If industrial capacity utilization is significantly lower than 79–83%, it will dampen the enthusiasm for manufacturers to invest, which means the problem of overcapacity.

The development of China's PV industry is unbalanced if we define the industry chain as upstream, downstream and installation. Supply of polysilicon in upstream and installation of PV power station are too small, while the products such as solar cells and components are too much, namely there are big supply and demand gaps in PV industry.

Fig. 6 implies that China's polysilicon production does not meet the demand though the production is increasing year by year. The demand of China's polysilicon was twice of the supply in 2012, and a lot of polysilicon had to be imported from abroad each year. What's worse, a majority of polysilicon companies were forced to stop with the rapid decline in price. According to research statistics of China Center for Information Industry Development (CCID), 80% of Chinese enterprises ceased production, the production capacity of which accounted for 50% of total in China. In the first half of 2013, the production capacity of polysilicon was approximately 90,000 t, and the output was about 31,000 t. There were still about 40,000 t polysilicon to be imported.

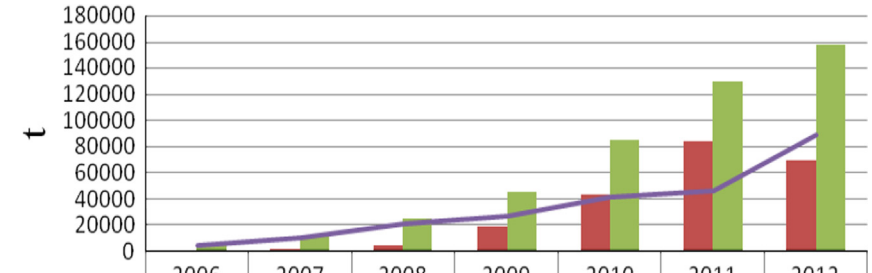
In China the application of the PV products concentrates on five sectors: (1) off-grid solar PV in remote and rural areas; (2) off-grid solar PV for telecommunications, meteorology, transportation and other industries; (3) off-grid solar PV for lights, chargers and other commercial products; (4) on-grid building solar PV which consists of integrated solar PV (BIPV) and building attached PV (BAPV); (5) large-scale (utility-scale) solar PV. The PV power installation is the main demand side of the upstream PV products. While the annual PV installation seems to be far less than PV cells, seen from Fig. 7. In 2012, the annual PV production was 22,000 MWp while the annual installation was only 4500 MWp, which means the gap was 17,500 MWp and many products had to be exported to other countries.

2.2.3. Export of PV products

The main exported countries of China's PV products are the EU, the USA and Japan. The primary exported products are solar cells and solar power station. China's PV product is export-dominated, and only about 20% of the products have been applied in domestic market. However, the global financial crisis, the European debt crisis, and the anti-subsidy investigations conducted by EU and the USA made the demand in foreign markets for PV products become weaker. Fig. 8 shows, the total exports of PV started to increase from 2008, and reached a peak in 2011 with the amount of $35.82 billion. However, it then began to decline rapidly to $12.29 billion at the end of 2013. The export growth rate also had been declining all the way from 2008 to 2013, and it was 47.25% in 2013.

2.2.4. Technologies

China's PV industry chain has formed and evolved due to the R&D support. The first crystalline silicon PV cell was successfully developed in 1958 and now China has formed its own PV industry chain. The chain consists of several stages: (1) upstream: purify silicon, shape it into ingots and then slice the ingots into thin wafers; (2) downstream: cut the thin wafers into desired dimensions and shapes to make solar cells, and then connect and laminate the solar cells to form a solar module; (3) installation: assemble the solar module in array and combine with electrical components to make a PV system. China's PV



	2006	2007	2008	2009	2010	2011	2012
Supply	290	1139	4500	18300	43500	84000	69000
Demand	4686	11500	25500	45000	85000	130000	158000
Gap	4396	10361	21000	26700	41500	46000	89000

Fig. 6. Supply and demand of China's polysilicon.
Source: [23].

	2005	2006	2007	2008	2009	2010	2011	2012
Annual production	200	400	1088	2600	4011	10500	21000	22000
Annual installation	8	10	20	40	160	500	2700	4500
Gap	192	390	1068	2560	3851	10000	18300	17500

Fig. 7. Annual production and annual installation of PV products in China (MWp).

Fig. 8. Export of China's PV products.
Source: [24].

industry has gone from small to large in scale, from single arrays to multiple arrays in type, and from low to high in conversion efficiency.

However, polysilicon material production technology mainly lies in the American firms (Hemlock, Asimi, SGS, MEMC), Japanese firms (Tokuyama, Mitsubishi, Sumitomo) and Germany firms (Wacker and other 6 ones). The large firms then formed a serious technology blockade and monopoly.

The overall Chinese PV technology still lies at a relatively low level and most enterprises lag behind the world advanced level in the conversion efficiency of solar cells and modules (Table 8). China also falls behind other leading countries in technologies such as high pure silicon, new and efficient solar modules, and high concentrated PV batteries.

3. Development trend and discussion

The phrase "turning point" in this article should be defined as a time point marked with an essential or a historical change instead of a point when things just get better than before. Whether and when the turning point of China's PV industry will come is a complex issue, and the mark of the turning point is that the key obstacles are cleared and then the large-scale of China's PV power market is achieved. First, this part selects three typical quantitative indicators for analysis, namely PV parity price, revenues and benefits of PV enterprises, and installed capacity, in order to determine industry development trend. Then factors that influence the trend are discussed.

Table 8
Solar cell efficiency.
Source: [3,25].

Type of PV cells	Maximum efficiency in Laboratory (%)		Commercial maximum efficiency (%)	
	China	International	China	International
Monoslicon PV cells	20.4	25	19	22
Poly-crystalline Si PV cells	> 20	20.3	16	16.9
GaAs PV cells	29.25	42.3		> 26
CIGS PV cells	14.3	20.3		15.7
CdTe PV cells	13.38	16.7		8–10
Fuel-sensitized PV cells	8.1	11.1		
HIT	17.27	23		

3.1. Development trend

If the PV grid parity comes true, the PV electricity will become competitive with conventional electricity, which will create demand for PV power market. Revenues and benefits reflect the operation performance of PV enterprises, good revenues and benefits will encourage suppliers of PV market to manufacture more products. The increase of China's PV installation is a good sign that the large-scale of China's PV power market will come sooner or later.

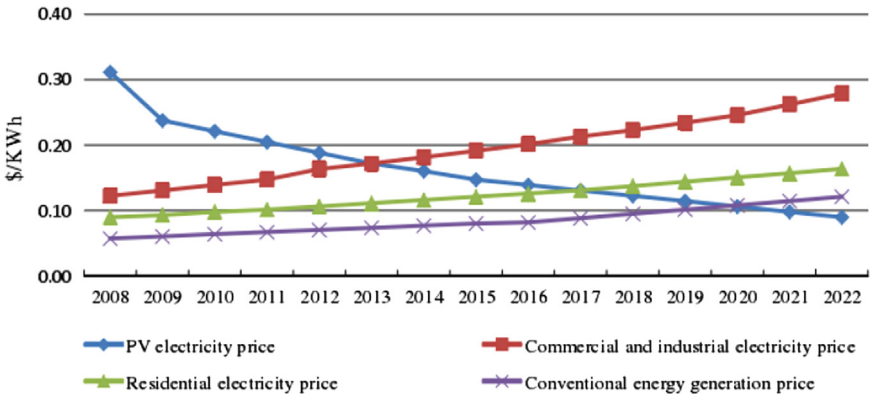


Fig. 9. China's PV grid parity projections.
Source: [26].

(1) PV grid parity projections
With government support in China, the development of PV technologies as well as the large-scale production, the price of electricity generated by PV has declined, and will be gradually reduced. In regions of rich light resource, cost of large-scale PV ground station electricity was close to $0.09822/kW h in 2012. On the other hand, conventional energy costs are most likely to increase due to the rising prices of gas, oil and coal, and the internalization of external costs to reduce carbon dioxide. Thus, the price of electricity generated by PV will become equal to or less than the price of conventionally generated electricity in another five to ten years [5]. Fig. 9 indicates that the PV electricity price would become equal to commercial and industrial electricity price in 2013 (in fact, it has come true), and it will equal residential electricity price in 2017 and conventional energy generation price in 2020.

(2) Revenues and benefits
There were hundreds of PV companies in China, and 70% out of 33 a-share IPO PV companies began to make money, and 8 companies have doubled net benefits in 2013. In this part, we use the sum of total revenues and net benefits of big ones (Suntech Power, Jinko Solar, Rene Solar, Yingli Green Energy, Hareon Solar, LDK Solar, Trina Solar, JA Solar, Baoding Tianwei, Hanwha Solarone), in order to analyze the operating performance trend of the PV industry. Fig. 10 shows the total revenues and benefits of the ten began to rebound in 2012, though the total benefits were still negative. However, we can't say that the year 2012 was the turning point for the rebound just released positive signals. We can make good forecast that the PV industry will be better and better based on Fig. 10, and the turning point will be on the way only when the whole industry really gains profits steadily.

(3) Installed capacity

"The 12th Five Year Plan for Renewable Energy Development" was emended that the target of cumulative solar power capacity was 35 GW by 2015 and 21 GW would be finished from 2013 to 2015. In May 2012, China's State Department issued "The 12th Five Year Plan for National Strategic Emerging Industry Development". In this paper, it indicated that China had established clear targets for the installation of PV systems. The NDRC adjusted the target of solar power installed capacity from 20 GW to 50 GW for 2020 [27].

It is said China's annual installation in 2013 was about 12,920 MW, and the National Energy Bureau has planned 14,000 WM PV installation should be finished in 2014. Compared to the wind power, installation proportion of the PV power was just 1.67% while the wind power was 7.4% in 2013. Fig. 11 shows the development trend of China's PV cumulative installation and

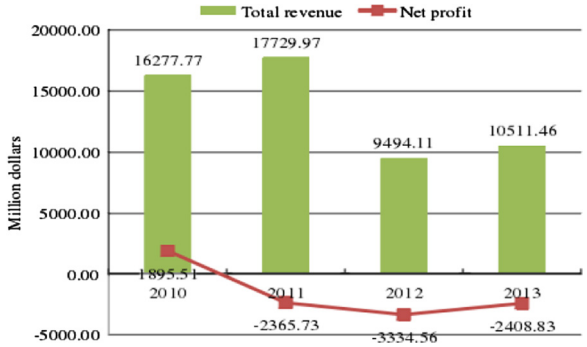


Fig. 10. Revenues and benefits of China's PV industry (sum up ten big ones). .
Source: Sina Finance website

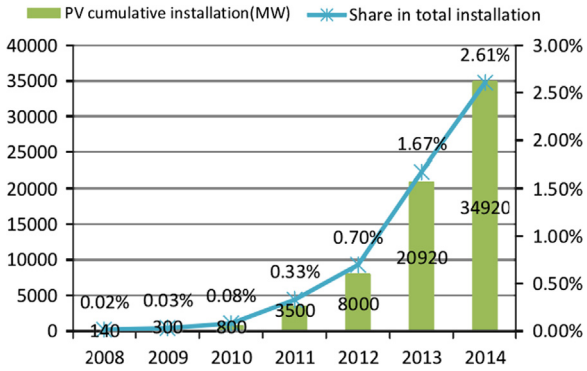


Fig. 11. China's installed capacity and share in total.

the PV installation proportion in total. It indicates that the installation and the proportion are increasing all the time and will go up in the future, which make the large-scale of China's PV power market a reality with high possibilities.

3.2. Discussion

The projections of the three indicators above are too superficial though they can give us good news, so more work and deeper analysis should be done. As can be seen from Fig. 12, the three grey block diagrams represent the three indicators, and blue block diagrams mean the 4 key obstacles that mentioned in 2.2 will be overcome.

R&D supports will result in technologies progress, and then the PV grid parity will come true with increase of the traditional electricity price and decline of the PV electricity price. Additional,

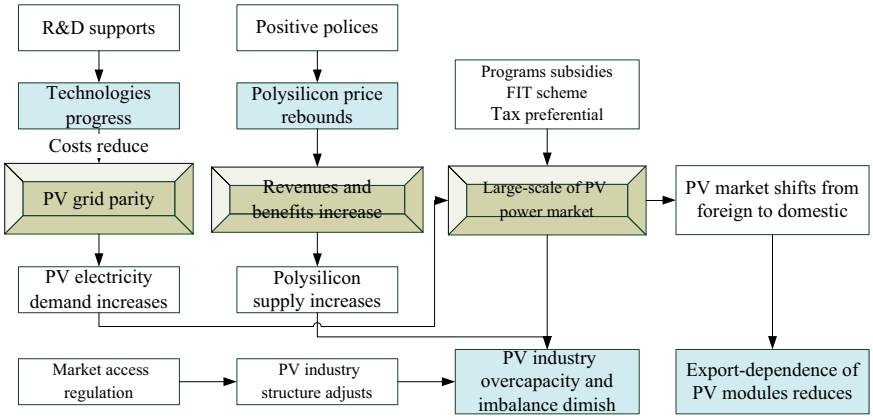


Fig. 12. Diagram of influenced factors interaction in PV industry.

based on the programs subsidy, FIT scheme and tax preferential, the large-scale of China's PV installation are to be realized without doubt. At the same time, the increase of PV companies' revenues and benefits also depend on various policies support. Fig. 12 also shows that all these factors, indicators and problems interact on each other. It is obvious that policies are very important in the interaction, and different policies have different effect.

Will the turning point of PV industry really come? It is can be seen that the four key obstacles are being cleared and the large-scale of China's PV power market will be achieved with the improved policies. Detailed analysis is made as below.

(1) Laws and policies which are the most necessary factors are introduced continuously. Mechanism has been established by the laws and related polices, which includes research, financial incentives, market access and tax incentives, and they covers the whole PV industry chain. What's more, "Renewable Portfolio Standards (RPS) Management Approach" will be released in 2013, aiming to guarantee the grid-connection ratio of renewable energy generation [28]. PV generation industry, besides wind power and biomass power generation, will be a key industry in renewable energy development.
Additionally, government revises or adjusts policies continuously to make them more perfect to adapt to the development of the PV industry. Take the FIT scheme and the related polices as examples. As the bid prices of the projects under the Concession Program were much lower than some solar industry participants had expected, energy power companies and private solar equipment suppliers were discouraged from investing in China's solar market. With a dampened financial incentive, project developers in China could barely break even, let alone got a decent investment return. Likewise, Chinese manufacturers have been putting pressure on Chinese government policy makers for better incentives. Then, In July 2011, the NDRC announced its first nationwide FIT scheme for solar PV development. It significantly motivates the development of China's solar power industry.

(2) PV products price will continue to rebound and the PV industry will gain money in a few years. From the 4th quarter of 2011 to the first quarter of 2013, upstream products price have been steady instead of decrease rapidly. Recently, PV polices were issued continuously which conveyed positive signals to the PV products companies. What's more, both China and Japan have expanded the PV installation market, which would increase the demand of the PV products. Therefore, prices should rebound to the level that at least can cover the cost.

(3) The problem of overcapacity will be solved for regulation for market access and expansion of the products demand. Regulation for market access on September17, 2013 sets requirements on production layout, production scale and technology. It is hoped to adjust the structure of China's PV industry chain, aiming at solving the problem of PV industry capacity and industry imbalance. In addition, the installation of the PV power has been expanded and the trend will go on, which will incentive the existed PV firms to produce more. So the overcapacity problem will also be solved.

(4) The condition of import-dependence and export-dependence will be changed gradually.
As for silicon, the demand of China's polysilicon was twice as the supply in 2012. Supply will increase if price rebounds or the cost reduces. Revenues and benefits of the PV manufacture firms began to rebound in 2012 and seem to keep this trend in the future. However, price is unlikely to rise sharply for the global polysilicon is too much and China's PV technologies still lie at a relatively low level. In a word, China's polysilicon will get rid of import-dependence gradually until more progress emerges in technologies.
The programs have expanded the application direction of China's PV power generation. For example, the Township Electrification Program represents that the Chinese government uses stand-alone generation systems of renewable energy power on a large scale to resolve the electricity needs of un-electrified areas for the first time. The Rooftop Subsidy Program and Golden Sun Demonstration Program have promoted the development of solar building projects (BIPV and BAPV projects). Thus, the program has stimulated the rapid development of China's solar PV industry to a large extent, and the influence will go on. China's capacity for production of PV modules has increased by ten times in a few years. In addition, the tax policy could encourage investors put more in PV power market. Thus, export-dependence of PV modules will reduce gradually. We know from Fig. 7, the gap between annual PV production and installation was about 18 GW in 2012. While the PV capacity of about 12 GW has been installed in just 2013 in fact, and 14 GW will be installed in 2014. Assuming the PV cell production increase slightly or without any increase, the gap will become smaller year by year gradually.

(5) China's PV technologies have been in continuous development though slow, and relevant policy support is insufficient. The 863 Program and 973 Program provide funding for scientific research and application in both upstream such as equipment manufacturing of crystalline and PV power application. The Rooftop Subsidy Program emphasizes generation efficiency. The regulation for market access such as "PV Manufacturing Industry Norms Condition" sets requirements on technology. It will prevent high-cost manufacturers entering, upgrade existing technology. "The 12th Five Year Special Plan for Solar

Power Technology Development" issues the target in "12th Five Year" period: (1) the efficiency of crystalline silicon cell is above 20% and silicon thin film cell is above 10%; (2) the cost of installation is $196.4572–212.8287/kW, and the price of on-grid utility-scale PV systems side is lower than $0.1310/kW h. Ultimately the technological level of the whole industry will be improved.

4. Conclusion and suggestion

In summary, here are the following conclusions: the turning point of PV industry in China will come in the future not later than 2020. The reasons are listed as follows: the PV grid parity will come true in 2020 completely and PV industry will gain benefit soon and the demand of the PV terminal market will substantially increase in a few years. What's more, the existed policies are adequate to contribute to the arrival of the turning point and the key obstacles on the way are being cleared up gradually. Considering the existed polices and mechanisms, following suggestions are proposed:

(1) Government should set up more ambitious target for middle and long term plan of PV power capacity. The renewable energy plan signifies that the government ensures a certain market scale and it is crucial in directing investment. However, the target of 50 GW for 2020 is too small. The government can set a goal such as 100 GW in view of planned total installation of 35 GW for 2015. We can see China's PV installation was more than 12 GW in 2013, and the installation will be 14 GW in 2014. What's more, government issued some new policies in 2013 to support PV industry, which would motivate the installation. Additionally, on January 13, 2014, the deputy director of NDRC and director of NEB Wu Xinxiong in national energy work conference pointed out that the development of solar power should be accelerated. Therefore, the average installation of 13 GW/yr is very possible.
(2) The cooperation mode of "Government-Enterprise-University-Research institution and Application" should be applied in China's PV industry. National PV technology research and development center should be established by government financial aid. According to status quo of China's PV industry, the main research contents of the platform can focused on several aspects: solar silicon materials preparation technology, crystalline silicon solar cell industry technology, solar cell detection technology, new type of solar cell research, system components and engineering research. At the same time, enterprises provide part of the funds for research institutions to do research and universities to train PV technological talents. Its essence is to promote the combination of technology, education and economy, which can cut down the PV power cost more quickly [29].
(3) China has to establish the trading system of green certificate. Industry unbalanced development was partly caused by policy itself [30]. At present stage, PV power development is immature. Necessary policies should be introduced to expand the market scale. When the time of low PV power price and the large-scale PV power comes, the policy interventions should be gradually withdrawn. The "invisible hand" of the market then will regulate the market by itself. Thus, government can adopt the trading system of green certificate. Tradable Green Certificate (TGC) system is a market that makes green certificate trade under the guidance of the price mechanism. PV power plants can not only sell the green electricity in Chinese electricity market, but also sell TGC in the green certificate market. So PV power plants can gain both income from electricity production and the benefits from the sale of green certificates. If the supply and demand of green certificates is balanced in TGC market, the equilibrium price of TGC is inversely proportional to the proportion of renewable energy in the total energy consumption. Adopting the trading system of green certificates means introducing the competition to market [31].

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